

EXHIBIT C1

**In the United States District Court
For the Eastern District of Texas
Tyler Division**

Halliburton Energy Services Inc.,	§	Civil Action: 06:05cv155
Plaintiff	§	
	§	(Jury Demand)
v.	§	
	§	Judge Leonard Davis
M-I LLC, Defendant	§	

Expert Report of Dr. Roger T. Bonnecaze

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1. Introduction

1.1. Purpose and Scope

I have been retained by Godwin Pappas Langley Ronquillo, LLP, counsel for Halliburton Energy Services, Inc. ("Halliburton"), to provide expert analysis and testimony in the above-styled cause with respect to certain issues related to the construction of claims in U.S. Patent Number 6,887,832 (the "patent").¹ In particular, I have been asked to opine as to the question of whether or not the specification adequately describes how to recognize fragile gel behavior in the claimed invention. This report reflects my opinions regarding those issues.

I anticipate testifying on some or all of the topics addressed by this report. In addition, if, prior to or at trial any other expert offers an opinion in my area of competence with which I disagree or upon which I have an opinion, I anticipate that I may comment on that opinion. In the course of that testimony, I may use some or all of the exhibits referenced by this report. Further, I may also use other demonstrative exhibits, summaries, or the exhibits that are not yet prepared to further illustrate my opinions. I understand that prior to trial, such exhibits would be exchanged with all other parties at a mutually agreeable time.

In the event of subsequent developments, including the availability of additional evidence, that may have a bearing on the opinions I have expressed in this report, I expect that I may supplement this report to take those

¹ I will use the shorthand "832" when referring to this patent. When I am referring to specific parts of the '832 patent, I will use the shorthand "Ccc:Lll," where "cc" and "ll" refer respectively to column numbers and line numbers in the patent.

developments into consideration or otherwise consider for the purpose of testifying at trial.

I am being compensated for my time in preparing this report and testifying about matters related to its substance at my usual and customary billing rate of \$350.00 per hour, and I am being reimbursed for my expenses. None of my compensation is based on the outcome of this lawsuit.

1.2. Background and Qualifications

I received a B.S. in Chemical Engineering from Cornell University in 1985. I received an M.S. and Ph.D. in Chemical Engineering from the California Institute of Technology in 1987 and 1991, respectively. I then performed post-doctoral work at Cambridge University from 1991-92. I have been employed at The University of Texas at Austin since 1993 as an assistant professor (1993-1998), an associate professor (1998-2002), and as a full professor (2002-present). As a professor of chemical engineering, I have taught and conducted research related to the rheological study, modeling and simulation of suspensions, emulsions, gels and soft particle pastes. I am currently a member of the Society of Rheology, the American Institute of Chemical Engineers, the American Physical Society, the American Chemical Society, and the American Society of Engineering Education. My *curriculum vitae* is attached to this report as Exhibit A and provides a more complete description of my education, background, qualifications, and publications.

1.3. Basis for Report

In preparing this report, I have relied upon a variety of materials that have been provided to me. A list of these materials is attached to this report as Exhibit B. In addition to my review of these materials, in preparing this report, I have relied on the experience I have gained through my research as a professor of chemical engineering at a major university.

I have been advised by counsel for Halliburton that the legal test for enablement is whether or not one reasonably skilled in the art could make or use the invention from the disclosures in the patent coupled with information known in the art without undue experimentation, and that a patent need not teach, and preferably omits, what is well known in the art. I have been further advised that there are many factors to be considered in determining whether or not any experimentation is “undue,” including but not limited to

- The breadth of the claims;
- The nature of the invention;
- The state of the prior art;
- The level of one of ordinary skill;
- The level of predictability in the art;
- The amount of direction provided by the inventor;
- The existence of working examples; and
- The quantity of experimentation needed to make or use the invention based on the content of the disclosure.

I have been further advised that Dr. Ronald K. Clark has opined that, for the purpose of evaluating the '832 patent, a person of ordinary skill in the art would have, at a minimum, a bachelor's degree in chemistry or chemical engineering, and at least five years actual experience in the formulation and use in the field of drilling fluids, or sufficient formal or informal training such that the person could appreciate the purposes of and variations on the proportions of the components of drilling fluids, including invert emulsion bases, emulsifiers, thinners, weighting agents and other common additives for controlling the filtration and rheological properties of the drilling fluid, and would have a working knowledge of the proper use, both in the field and in the laboratory, of the standard instrumentation used for obtaining measurements of drilling fluid properties, the interpretation of those measurements, and the application of those measurements to an active drilling operation.

I have been further advised that M-I has asserted that the patent fails to meet the 'enablement' requirement of 35 U.S.C. §112 because the patent's specification does not provide an explanation or disclosure of tests using a Brookfield viscometer that Halliburton used to distinguish between the prior art combinations of (a) an invert emulsion base, (b) an emulsifier, (c) a weighting agent, and (d) a thinner—which allegedly do not result in a fragile gel—and combinations of those four elements that do result in a fragile gel. This assertion, as discussed below, is untrue.

I have been further advised that M-I has asserted that "[n]o one can determine whether a drilling fluid is an infringing 'fragile gel' from reading the

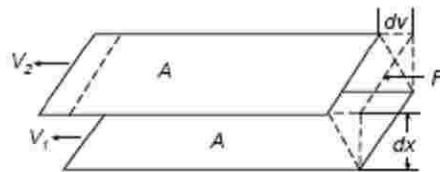
“832 patent ... There is simply nothing substantive in the patent, no point of reference for determination of infringement or non-infringement ... On this basis alone the claims are indefinite and thus invalid.” This assertion is also untrue, as is supported by the following.

2. Technological Background²

2.1. Fundamentals of Viscosity

Viscosity is the internal friction of a fluid, caused by molecular and other interactions, which makes it resist a tendency to flow. Viscosity becomes apparent when one layer of fluid is made to move in relation to another layer. The greater the viscosity, the greater the amount of force on a per area basis (known as the “shear force”) required to cause this movement.

Newton defined viscosity by considering two parallel flat areas of fluid of the same size “A” separated by a distance “dx” and moving in the same direction at different velocities V_1 and V_2 .



Newton assumed that the total force “F” or shear force “F/A”, where “A” is the area being sheared, required to maintain the difference in velocities “dv” was proportional to the difference in velocity throughout the liquid:

$$\frac{F}{A} = \eta \frac{dv}{dx},$$

² This technological background is derived from *Structure and Rheology of Complex Fluids* by Ronald G. Larson, Oxford University Press, New York 1998 and *Rheology: Principles*,

where “ η ” is a constant for the given material and represents its “viscosity.” The “shear rate” dv/dx is the measure of the change in speed at which the intermediate layers between the two areas of liquid move with respect to each other, and is often symbolized as “ γ .” The “shear stress” force/area represents the force required to produce the shearing action, and is often symbolized as “ τ .” Thus, viscosity can be defined as:

$$\eta = \frac{\tau}{\gamma}.$$

A material having a viscosity of one “poise” requires a shear stress of one dyne per square centimeter producing a shear rate of one reciprocal second. Viscosity measurements are sometimes shown as “Pascal-seconds;” one Pascal-second is equal to ten poise.

In Newton’s model, the viscosity is independent of the shear rate—that is, if the shear force was doubled, the shear rate would double. The viscosity of a “Newtonian” fluid, such as water, can be shown graphically by plotting the shear stress τ as a function of the shear rate γ , or alternatively, by graphing the viscosity η as a function of the shear rate γ :



Measurements and Applications by Christopher W. Macosko, Wiley, Johns and Son, 1994.

Not all fluids follow Newton's model however. In a "non-Newtonian" fluid, the relationship between shear stress τ and shear rate $\dot{\gamma}$ is not constant—that is, the shear rate does not vary in proportion to the shear stress. In contrast to Newtonian fluids, where the viscosity can be measured at any speed, the viscosity of a non-Newtonian fluid must be measured as a function of speed.

Some fluids decrease in viscosity when the shear force is increased. This type of behavior is often referred to as "shear-thinning." The viscosity of these "pseudoplastic" fluids can be graphically depicted as follows:

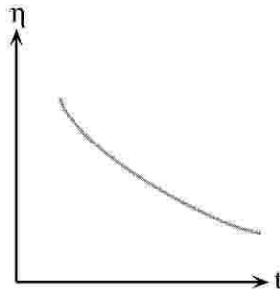


Some fluids will even behave like solids (or "plastics" or "gels") until sufficient shear stress is applied. Once the shear stress reaches the "yield point," these fluids will convert from plastics to fluids, exhibiting Newtonian or non-Newtonian viscosity:

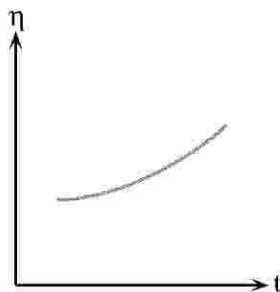


Non-Newtonian fluids can also exhibit changes in viscosity as a function of time. Given a constant shear rate, for example, the fluid may become less

viscous with time. This is referred to as “thixotropy” and can be graphically depicted as follows:



In contrast, a “rheopectic” fluid will become more viscous as time passes:



The gel strength of the fluid is the stress required to break the gel and initiate flow of the material. A gel is composed of an interconnected network that can support a stress, and if that stress is less than or equal to the gel strength, it will not flow. The network can be composed of particles or molecules. A homely example of the latter is gelatin, like Jello, which is composed of a network of protein molecules in water.

2.2. Causes of Viscosity and Gel Strength

The resistance to flow of a fluid, as quantified by viscosity and gel strength (if applicable), arises due to complex interactions among molecular constituents of the fluid. In addition, interactions among macroscopic constituents composing the fluid, such as droplets and solid and surfactant-derived particles, also contribute to the overall viscosity and gel strength of the

fluid. However, the combination of disparate and complex compounds in a drilling fluid greatly complicates the theoretical determination of viscosity and strength. For example:

- The components may interact to form stable structures (due to electrical and/or physical forces) that resist shear stress forces, but when the shear stress reaches a certain point, the structures are broken apart and the fluid may change from plastic behavior to pseudo-plastic behavior.
- An emulsifier may bring a non-polar molecule (an oil, for example) together with a polar molecule (water, for example), to form an emulsion that has a different viscosity and gel strength than the oil or water when considered separately.
- The interactions among the constituents of the fluid are sensitive to changes in temperature, making viscosity and other rheological properties temperature dependent.

While one of ordinary skill in the art might be able to make some limited qualitative predictions about how the various interactions within a given drilling fluid may change the rheological behavior of the fluid, even one of extraordinary skill in the art would have difficulty in accurately predicting the exact rheological behavior. As such, the best way to ultimately determine that behavior is through experimentation. Such experimentation is discussed in the following section.